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BUREAU OF MINES
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MINE-FAN SIGNAL ALARMS AND POWER RELEASES

BY

W. J. FENE AND H. F. WEAVER

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

MINE-FAN SIGNAL ALARMS AND POWER RELEASES[1/]

By W. J. Fene[2/] and H. F. Weaver[3/]

Ventilation is undoubtedly the greatest single safety factor in the operation of a coal mine. Any condition or occurrence that interrupts the ventilating current or changes its normal course through the mine workings is a distinct hazard and should be considered as such by every coal-mine owner, operator, and worker. The hazard, of course, is much greater in a mine that is emitting gas, as an explosive mixture can accumulate in a very short period if the ventilating current is interrupted. It is common to find one or more entries producing 600 cubic feet or more of methane per hour. If the ventilating current were short-circuited from these entries for 15 minutes, there would be an accumulation of 150 cubic feet of methane, which, when mixed with enough air to dilute it to the lowest explosive point, would make about 3,000 cubic feet of explosive mixture; this gas could be ignited in almost any normally operated mine by a cutting machine or other electrical equipment. The ignition of this quantity of an explosive gas-air mixture can readily cause an explosion of coal dust that would completely wreck the underground workings and possibly some of the surface structures. In fact, the ignition of one-tenth of the above quantity of an explosive mixture of gas and air might readily start an explosion that would extend through every part of a large mine.

The possibility of occurrence of interruptions to the ventilating current has received comparatively little consideration from mine owners, operators, and workers in many parts of the United States. Such a possibility should be considered in connection with every mine that gives off explosive gas, and steps should be taken to prevent it.

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If the ventilating fan should stop, with a resultant accumulation of explosive gas, it would be impossible to ignite it by electrical arcs or sparks if the electrical power were cut off at the surface.

At some mines the power is supposed to be cut off by an attendant on the surface when he observes that the fan has stopped; this method is by no means dependable, although it might be more satisfactory if the attendant were always near the fan and the switches controlling the underground circuits were opened immediately after the fan stopped. However, the attendant is not always near the fan, and enough time might elapse before he observed that the fan was stopped to allow an accumulation of explosive gas to be ignited before the circuits were opened; frequently the fan has no attendant. A fairly satisfactory method has been adopted at some mines - the installation of devices that automatically open the underground circuits when the fan ceases to function or when the ventilating current is reduced to some predetermined velocity.

Several different types of power release and signal alarms in use are described in detail in this paper. It is believed that a device of this kind or any other device that serves the same purpose should be installed in every mine in which explosive gas is emitted, but it should be installed in such a way as not to interfere with the hoisting cages that are used to bring employees to the surface; the hoists that control these cages should operate from a separate power line. In some States the mining law now makes the use of such devices compulsory.

If the fan stops and the power is disconnected for more than a few minutes,in a mine that gives off explosive gas, the men should be removed from the mine. After the fan has resumed its normal function and has been operating normally for at least a few hours, thorough inspection should be made of all the underground workings before the men are allowed to return to work.

Description of Several Types of Automatic Power Release and Signal

The several types of power release and signal described are based on difference in ventilating pressure or on fan speed for their operation. In one type, the release of pressure against a vane operates the contact points,of a switch, and in other types the contact points are closed when the air pressure is equalized on two sides of a wall.

Figure 1 shows the type of power release and signal used by the Victor American Fuel Co. at its Colorado mines. The device consists of an aluminum vane about 1/32 inch in thickness and approximately 16 x 18 inches in area. The size of the vane is based upon the velocity of the air in the fan drift where

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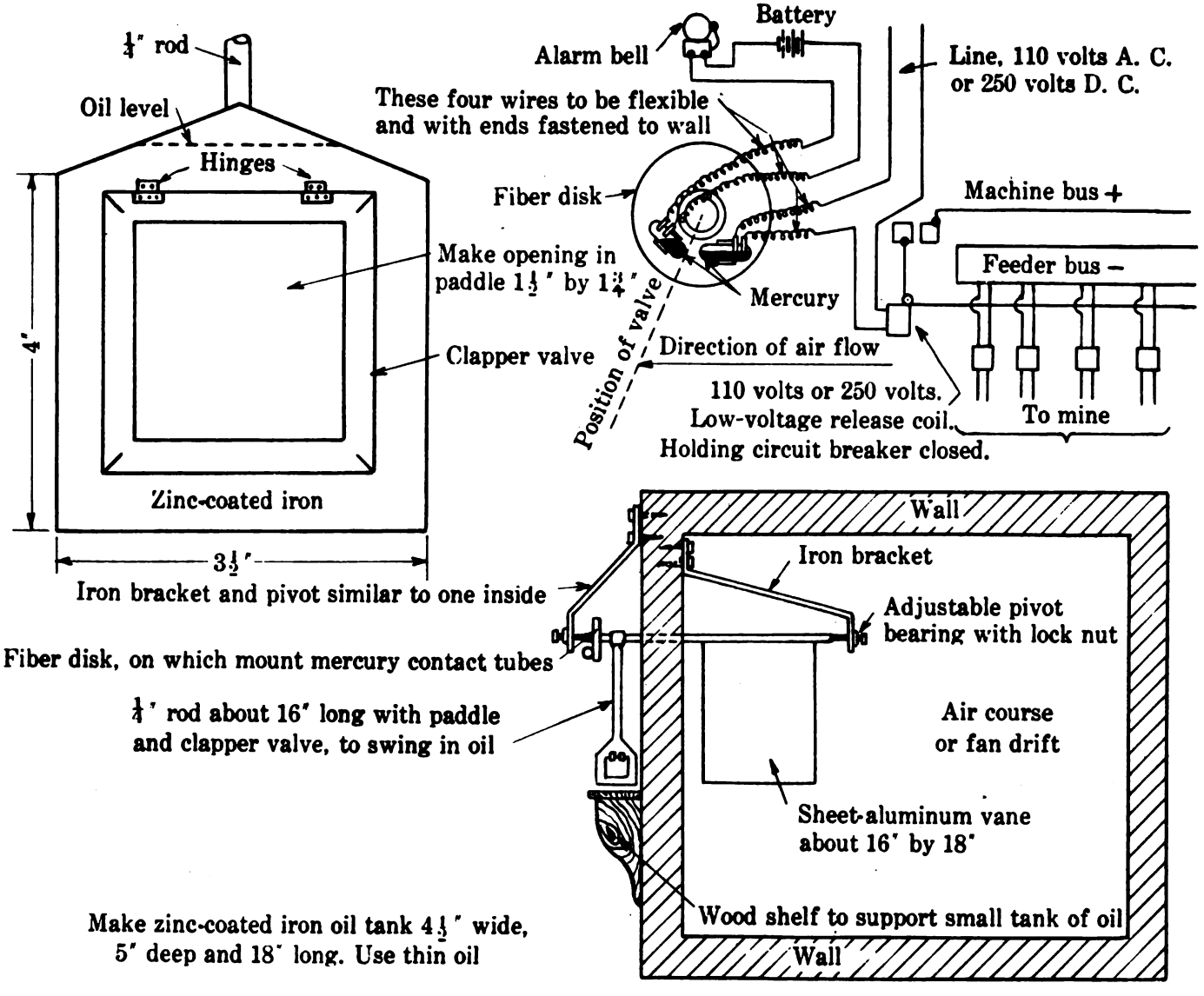
¼" rod
Oil level
Hinges
4'
Zinc-coated iron
3½"
Iron bracket and pivot similar to one inside
Battery
Alarm bell
Line, 110 volts A. C. or 250 volts D. C.
These four wires to be flexible and with ends fastened to wall
Fiber disk
Machine bus +
Feeder bus –
Make opening in paddle 1½" by 1¾"
Mercury
Clapper valve
Position of valve
Direction of air flow
110 volts or 250 volts.
Low-voltage release coil.
Holding circuit breaker closed.
To mine
Wall
Iron bracket
Adjustable pivot bearing with lock nut
Fiber disk, on which mount mercury contact tubes
¼" rod about 16" long with paddle and clapper valve, to swing in oil
Air course or fan drift
Sheet-aluminum vane about 16" by 18"
Wood shelf to support small tank of oil
Make zinc-coated iron oil tank 4½" wide, 5" deep and 18" long. Use thin oil
Wall

Figure 1.—Automatic power release switch operated by ventilating current.

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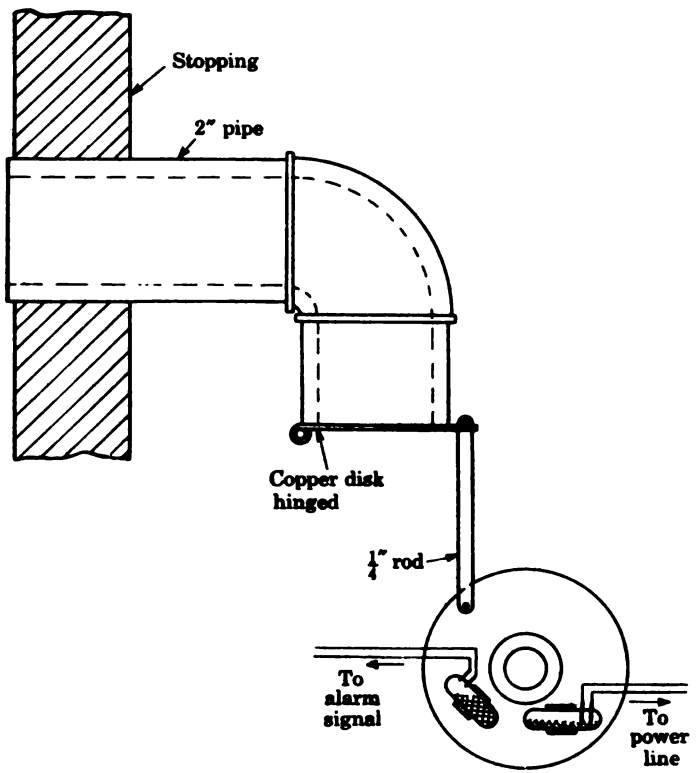

Figure 2.—Cross section of power release used in entry stopping or fan drift.

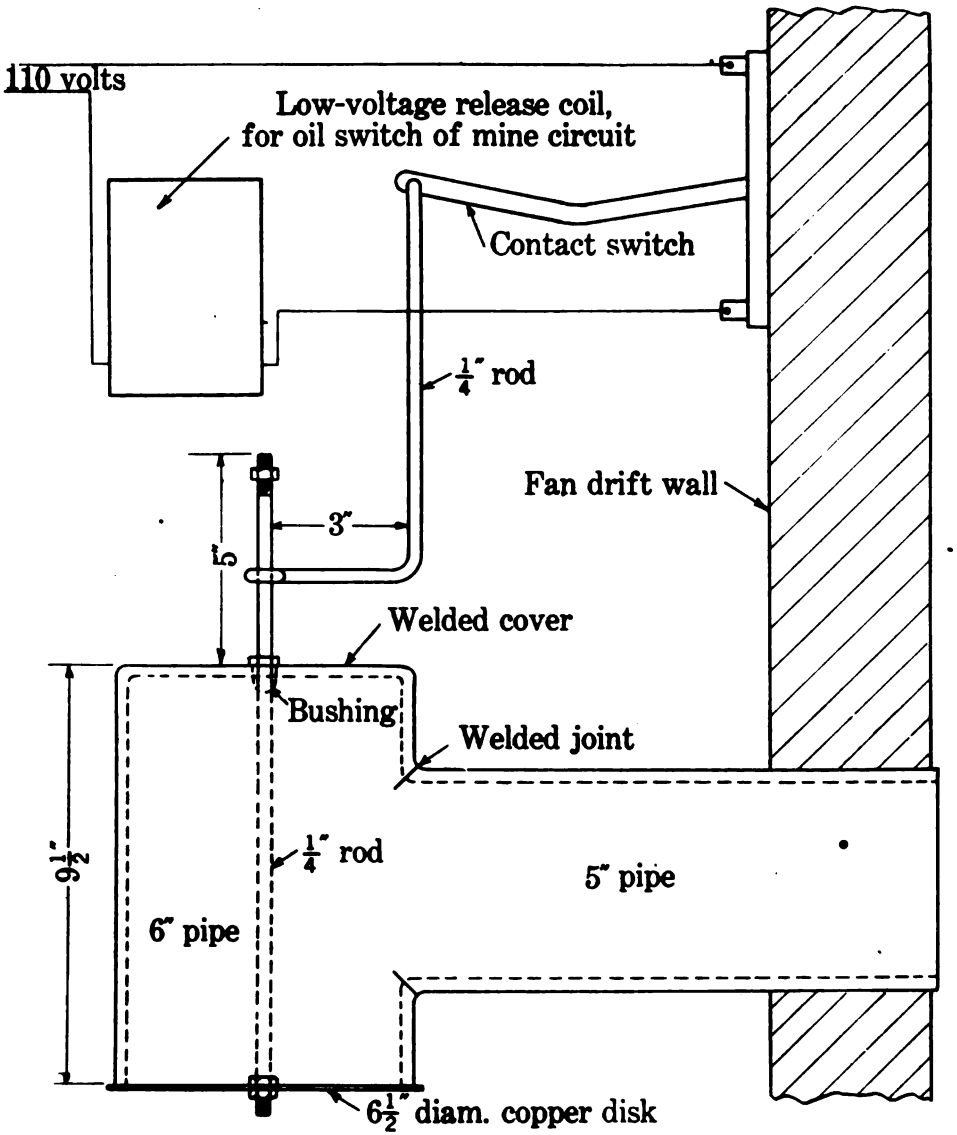

Figure 3.—Cross section of Shaw automatic power release.

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it is to be used. This van is mounted on a small shaft about 1/2 inch in diameter and is supported between two iron brackets, one on the inside of the fan drift and the other on the opposite side of the wall in the motor room. One end of each bracket is drilled and tapped to hold a brass screw having a hole bored in one end to support the pointed ends of the van shaft. These brass screws are fitted with lock nuts to hold them in proper adjustment. A paddle arm about 16 inches long, made of 1/4-inch steel or iron rod, is mounted on one end of the vane shaft by means of a set screw, or is welded to the shaft. On the other end of the paddle arm is a small galvanized sheet-iron paddle about 3-1/2 inches wide and 4 inches long. In this paddle a hole about 1-1/2 by 1-3/4 inches in size is cut, and on one side a small piece of the same material is hinged. This "clapper valve" overlaps the hole in the paddle about 1/4-inch on all sides. To prevent undue movement of the paddle due to slight variations in the ventilation pressure, it is submerged in oil in a galvanized-iron tank about 4-1/2 inches wide, 5 inches deep, and 18 inches long. Ordinary engine oil is suitable if outside temperatures are not extreme, and a little kerosine will thin the oil in very cold weather. Two mercury contact tubes are mounted on the face of a fiber disk about 1/2 inch in thickness and approximately 6 inches in diameter, and keyed or fastened to the vane shaft. Brass clips similar to those on enclosed fuse blocks may be used to mount the tubes on the disk. These clips are drilled with one hole in the center and bolted to the fiber disk with about a 1/4-inch stove bolt, which makes a convenient fastening and permits adjustment of the level of the tube to the proper angle so that the contact pieces within the tube are submerged to the proper depth in the mercury when the contacts are closed. The mercury tubes contain a gas that prevents corrosion of the contact points, and as there is no open arc when contact is made there is no danger of ignition of gas that may be present. One tube is used to make and break the current taken from any 110-volt alternating-current or 250 volt direct-current lighting circuit. The contacts in this tube are in series, with a low voltage release coil controlling a circuit breaker inserted between the machine busbar and the feeder busbar. The low-voltage release coil, of course, must be wound for the voltage that is to be used through the contact tube. The other tube is so placed that when the vane returns to a vertical position the mercury flows toward the contacts and closes the alarm bell circuit. This alarm bell can be placed at any location and as many can be used (placed at various points on the property) as are desired. Batteries may be used for this circuit, but alternating-current power and bell transformers can be substituted for batteries.

Figure 2 shows a type of automatic power release and alarm that may be used in an entry stopping or fan drift. It utilizes the effect of the release of suction to operate the mercury contact tubes. This device consists of a 2-inch pipe, long enough to extend through a stopping or wall and about 8 inches to one side. To this pipe is connected an L, the open end of which has been ground to make a tight seat with the light copper disk that is hinged to the lip

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of the L. Opposite the hinge on the copper disk, a 1/4-inch rod is fastened to serve as an arm to move the mercury tubes when suction is released and the copper disk drops. The mercury tubes are mounted in a way similar to the one describes for the device shown in figure 1.

Figure 3 shows the type of automatic power release developed and used by the Consumers Mining Co. at its Harmarville (Pa.) mine. The device consists of a piece of 6-inch pipe, 9-1/2 inches long, to one end of which has been welded a piece of iron or steel plate a 5-inch hole is cut into the side of the 6-inch pipe, into which a 5-inch pipe is welded, forming a T. The length of the 5-inch pipe varies with the thickness of the fan drift wall. A 3/4-inch hole is bored through the plate, previously welded to one end of the 6-inch pipe, and a bushing with a 1/4-inch hole supplied. A 1/4-inch rod about 15 inches long is attached to a copper-sheet disk about 7 inches in diameter. This rod is inserted through the bushing with a copper disk over the open end of the 6-inch pipe. Another 1/4-inch rod bent to form an L is attached to the rod extending through the 6-inch pipe and to the lever arm of a contact switch.

The 5-inch pipe is placed through the wall of the fan drift in the suction side of the fan, about flush with the inner side of the wall. The switch used may be of the contact or float type, and is connected in series with a low-voltage release coil controlling an oil switch for the mine circuit. When the fan is operating, the copper disk is held flush against the bottom of the T because of suction of the air. When the fan stops, the disk will fall of its own weight and throw the switch that operates the low-voltage release coil, which in turn controls the oil switch for the mine circuit.

Figure 4 shows an automatic power release and signal arrangement developed and used by the Colorado Fuel & Iron Co. The arrangement of this device is somewhat similar to the one whown in figure 1, with the exception that a U-tube is used instead of a vane and a relay panel controls the signal bell and opens the release coil on the mine power circuit.

To obtain the maximum travel of the float where small pressures are used, or small travel where the pressure is greater, it is necessary for the U-tube to have one large and one small leg. A float carrying a cup containing mercury, which is covered with transformer oil to extinguish the arc, is placed on one leg of the U-tube. Transformer oil, salt water, glycerin, or any other liquid that will not freeze readily should be used in the U-tube.

Figure 5 shows a simple arrangement designed to give a signal warning when the fan stops or slows down. The device consists of a U-shaped pipe, a cork float on which is mounted a cup containing mercury, suitable copper contacts, and necessary lead wires. The U-pipe is placed in the wall of the

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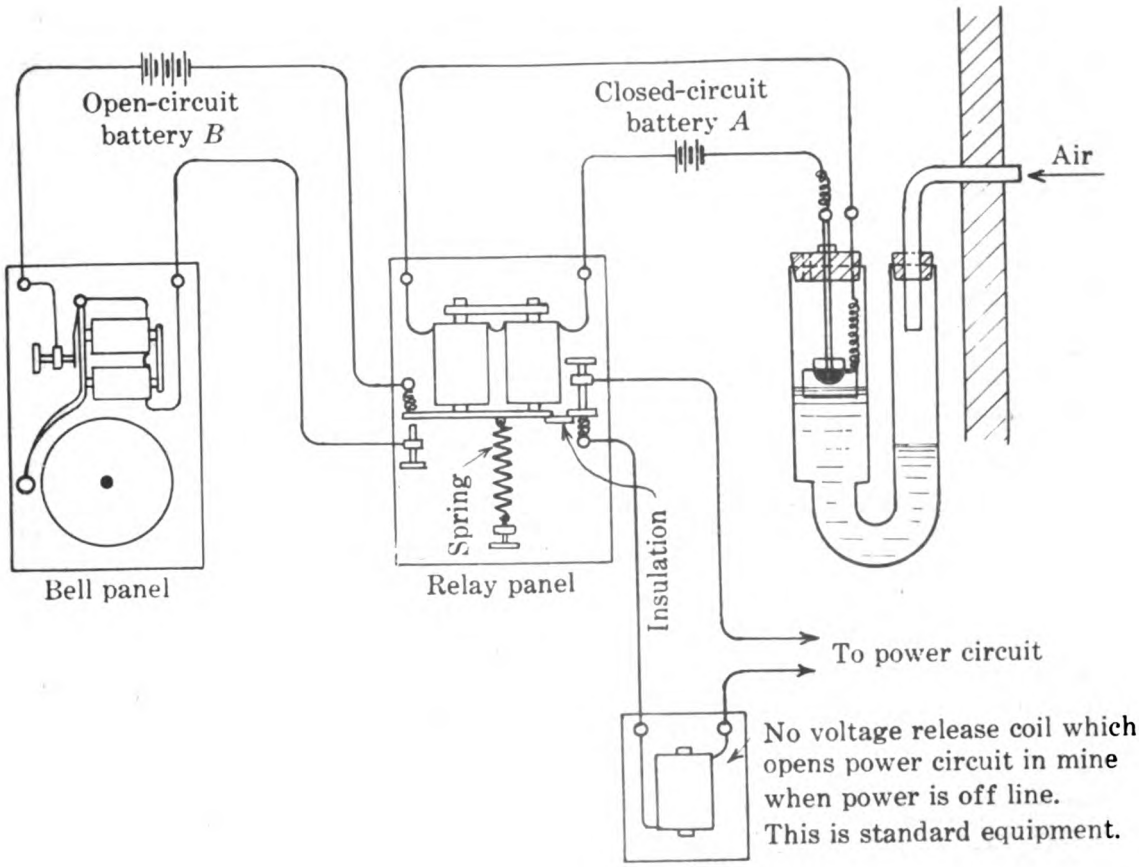

Figure 4. — Automatic power release and fan signal.

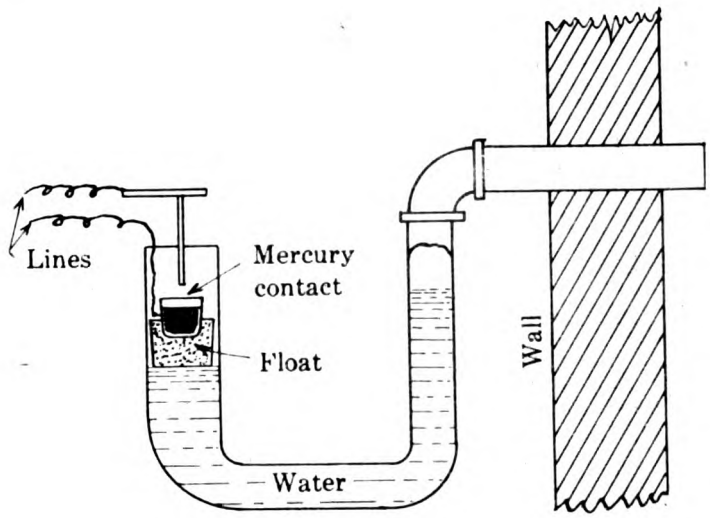

Figure 5. — Automatic fan signal.

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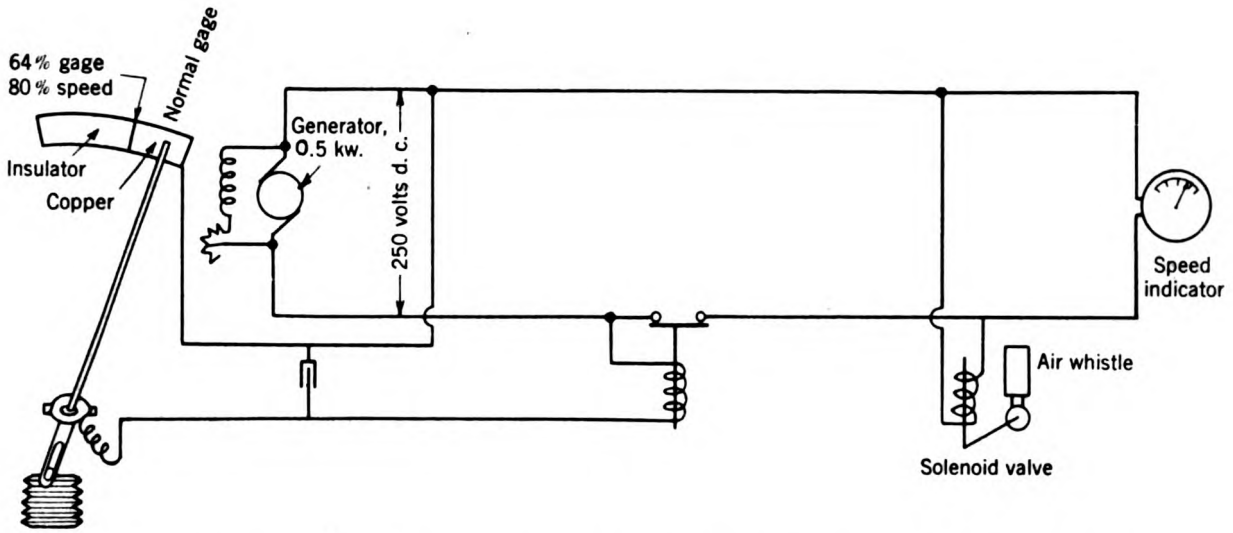

Figure 6.—Water-gage alarm. Will operate on either over or under pressure. Severe closure of airway moves the arm above contact; severe short circuit drops the arm below contact.

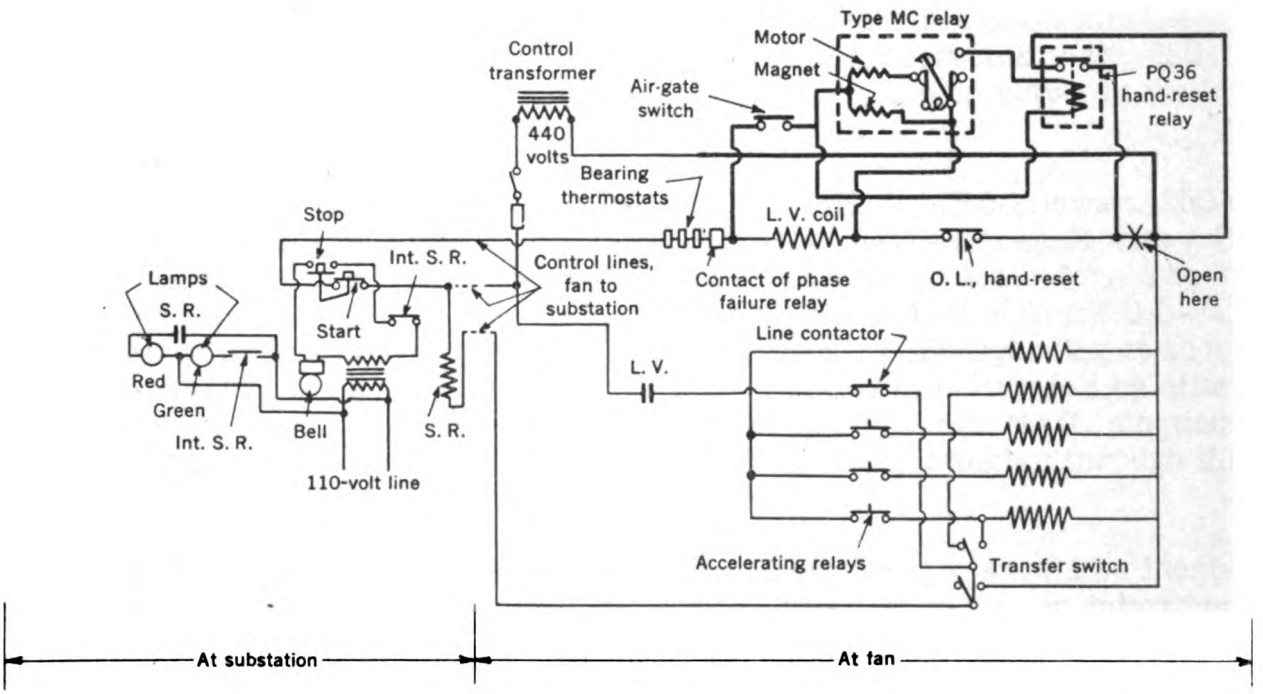

Figure 7.—Timing relay used in alarm added to fan control.

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fan house with the U on the outside and the other end extending into the intake. The U-pipe is filled with salt water, glycerin, or any other liquid that will not freeze at temperatures likely to be encountered.

As long as the fan operates at its rated speed, the level of the liquid in the short leg of the U will be pulled down, carrying the cork with it; slowing down or stopping of the fan allows the liquid to rise, making contact with the mercury and copper strip attached to one of the lead wires. The circuit is then completed and the signal bell rings, giving warning that the fan has slowed down or stopped.

Figure 6 shows a fan-failure-alarm signal system devised by the Pennsylvania Coal & Coke Corporation. It consists of two signaling elements. One element is a modified Bristol water gage with the hand mounted on a bridge from a Westinghouse ammeter, and contacts added. The moving element is insulated and attached to the water-gage bellows through a slotted section, by which the vertical motion of the pin on top of the bellows is changed into a circular motion of the contact arm. The stationary contact is of such length that if the contact arm were moved beyong maximum normal gage it would break contact; also, if the contact arm dropped below the lowest desirable gage, contact would be broken, opening the circuit of a contactor in the 250-volt direct-current control circuit, which releases a solenoid valve on the air-pressure system causing an alarm whistle to blow.

The other element in the signal system consists of a 0.5-kilowatt, 250-volt, direct-current generator which is belted direct to the fan shaft with a "V" belt, and connected to a millivolt-ammeter used as a speed indicator. The speed indicator is calibrated by belting a variable speed motor to the 0.5-kilowatt generator and driving the generator at speeds corresponding to the speeds it would be driven by the fan. The water gage was calibrated by attaching it to a pipe, extending down 25 feet from the top of the air shaft, plugged at the end, and having four 1/16-inch holes drilled at right angles through this pipe about 1 inch from the plugged end.

Both the speed-indicating meter and the alarm whistle should be located at the motor repair shop or at some other place where men are on duty when any person is in the mine. The air pressure required to operate the whistle is obtained from an auxiliary tank connected, through a check valve, to the regular compressed-air system.

The Lehigh Navigation Coal Co., Inc., added air-gate switches and the necessary relays to its full-automatic and remote fan controls in order that, in addition to having a motor-failure alarm, an alarm would sound if a belt broke or slipped or if the ventilating pressure failed. The alarms are placed

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at the main substation, where an attendant is always on duty. Selection of the proper relays for installation at the fan made it unnecessary to run additional control lines from the fan to the substation.

An air gate was fastened over a hole cut in the fan housing, and the air-gate switch was attached to the brick wall of the fan-motor room. The gate is a 15-3/4 by 5/16-inch steel plate suspended on a hinge pin from which a lever and rod transmit the motion to the switch. When the fan is in operation, air pressure fails, the gate swings by gravity to a vertical position. Normally the gate switch is open, but when the air pressure fails it is closed.

Heavy lines in the wiring diagram (fig. 7), which includes only control circuits, indicate the connections which were added to install the air-gate switch and two relays. This type MC relay is set at a point between 30 seconds and 1 minute. When the air-gate switch is closed because of ventilating pressure - positive or negative depending on whether the fan is blowing or exhausting - timing of the MC relay begins. Its final operation opens the contacts of the PQ 36 hand-reset relay, which in turn deenergizes the low-voltage contactors. That action deenergizes all contactors. When the SR relay opens the red lamp, which indicates normal operation, is turned off, the green lamp lights, and the bell is sounded. When the starting button is pushed for normal starting of the fan, the low-voltage coil becomes energized to close its contacts, which in turn energizes the MC relay through the air-gate switch and the line contactor to start the motor. If the motor accelerates properly and comes up to speed before the MC relay has had time to act the air gate is pulled to operating position by the air pressure, and the air-gate switch thus deenergizes the MC relay. During the normal starting period the closing of the final contactor, which short-circuits all rotor resistance, also operates the transfer switch; one of the functions of this transfer switch is to close the SR contactor, thus lighting the red lamp and deenergizing the bell, which has been ringing during acceleration.

Figure 8 shows a signal developed by the Knox Consolidated Coal Corporation and provides a signal in case of fan stoppage. A 3/4-inch pipe was tapped into the discharge end of the fan casing, and air flowing through the pipe blows against a paddle mounted on a ball bearing. The paddle in turn holds the contact in the closed position, but if the fan should stop the paddle drops back, opening the contact and breaking the circuit to a magnet weight causing a whistle to blow.

Figure 9 shows another economical and practical method to indicate by visual and audible signals the stoppage of the ventilating fan. The drive pulley can be installed at any point on the fan shaft but usually is bolted onto the center of the end that is most convenient. Any small direct-current motor may be used as a generator if driven slightly above its speed as a motor. The volta

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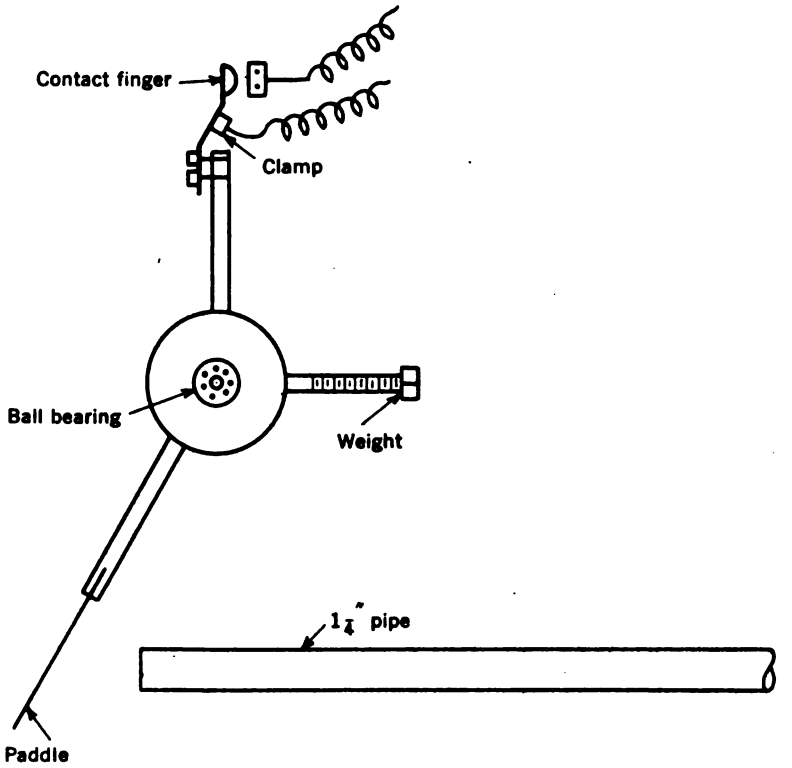

Figure 8.—Sketch of fan-operation indicator.

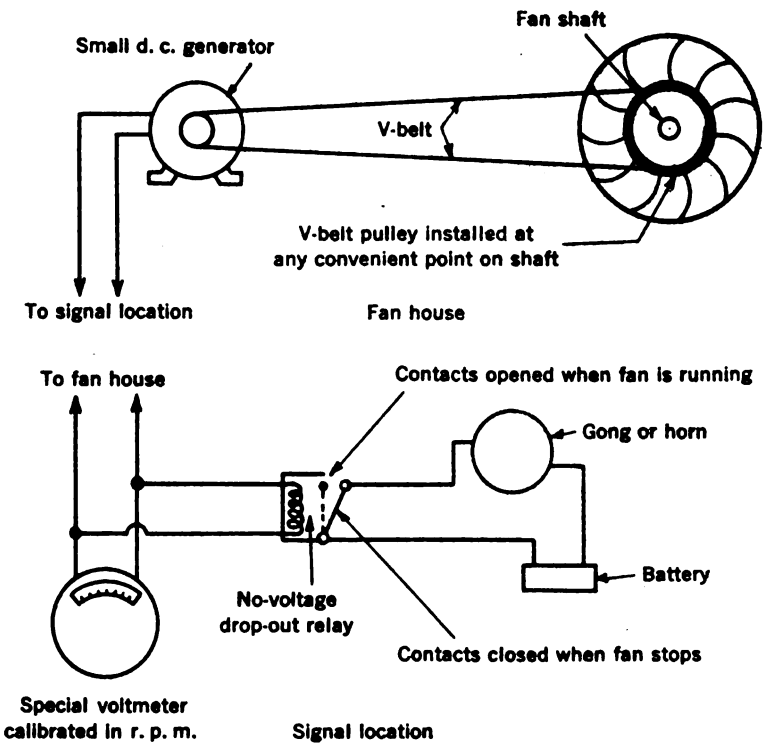

Figure 9.—Details of fan signal system.

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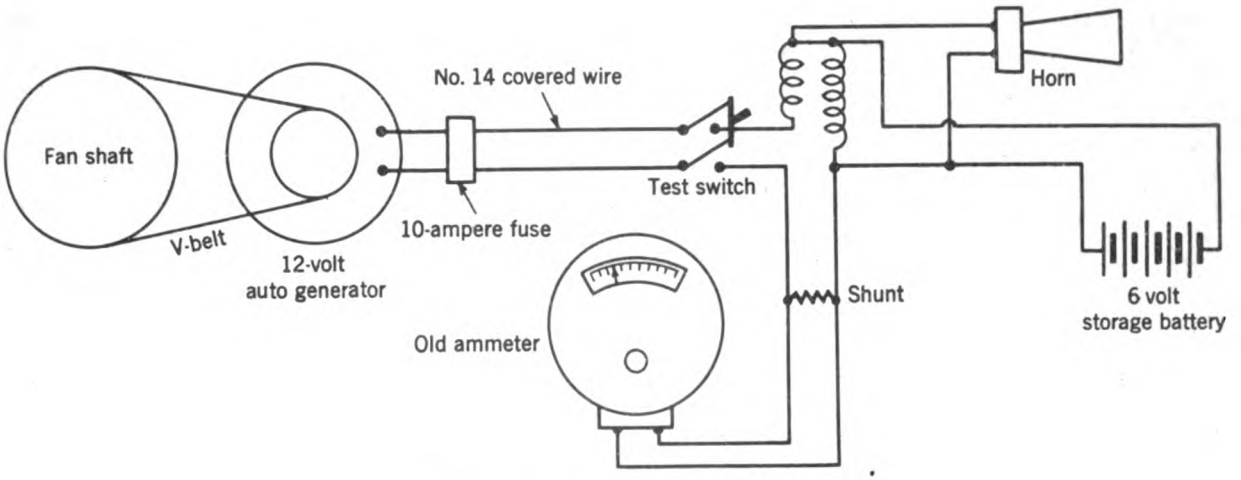

Figure 10.—Sketch of fan signal system.

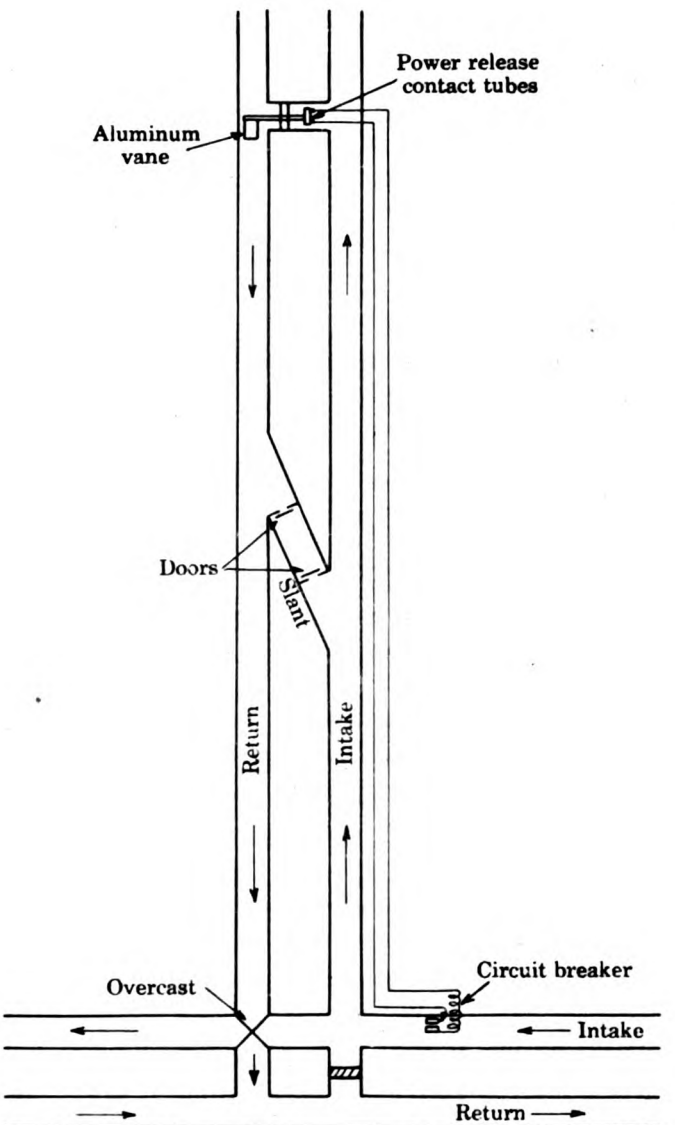

Figure 11.—Plan of power release in an entry or split.

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generated will bear a definite relation to the speed, so that a voltmeter can be calibrated in revolutions per minute instead of volts. Ordinarily, where the fan is operated at several speeds, this calibration is made by actual runs after the equipment is installed so that the readings are correct. Any small drop-out contactor can be used, for voltage is induced only when the fan is in operation.

The signal can be any audible indicator which is operated by a storage battery to give a positive source of power. If the fan operation or the line or generator fails, the r.p.m. meter will drop to zero, and the audible signal will sound.

Figure 10 shows the wiring system of a signal to disclose fan operation or stoppage at the mines of the Cambria Fuel Co. A 12-volt generator, salvaged from an automobile, was fastened to the fan bearing and driven by a "V" belt. Telephone wire was used for the circuits and an old ammeter installed to show the fan revolutions. In making the installation the cut-out was removed from the generator, and the original large winding was replaced with 40 turns of No. 25 B. & S. wire so that it would oppose the 6-volt coil and hold the cut-out open until the fan slowed down. Upon slowing of the fan, the cut-out closes and causes a horn to blow; the horn motor is supplied with power from a 6-volt storage battery. In this wiring plan, the generator is also used to charge the horn battery (1/2 mile of circuit will consume 6 volts, leaving the rest for battery charging).

Use of Automatic Power Releases and Signals Underground

Numerous explosions have occurred during recent years because doors have been left open during the work shift; this short-circuiting of the ventilating current allows gas to accumulate, and carelessness with electricity or open lights has brought about ignitions, with numerous fatalities.

Doors for controlling ventilation should be eliminated insofar as possible, but where they are used they should be protected by a signal- and power-release device to give warning and to turn off the power from that particular section of the mine when the door has been left open. Some of the devices previously described can be used for this purpose. Preferably doors should be installed in pairs, with enough space between them to permit a trip of coal to pass through without having both doors open at the same time, but where at all feasible overcasts should be used rather than doors.

Figure 11 shows an arrangement of a power release on an entry or split, using the device shown in figure 1. In airways or entries where the vane might interfere with any of the mine activities, any of the U-tube types of power

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releases may be used. To eliminate the possibility of gas or dust being ignited from the circuit breaker, it should be of the enclosed oil type and located on the main entry in pure intake air. These underground installations should be adequately protected to prevent damage from falls of roof.

The automatic power releases and signals described herein may be used to advantage at any gassy mine. Besides being factors of safety in releasing the power and giving warning when the fan stops running or a door is left open, at many mines they also eliminate the use of a fan attendant. These devices are not manufactured for sale; however, they are simple in design and installation and can be made in most mine machine shops.

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